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# SCALE ANALYIS OF YUKON RIVER CHUM SALMON

1974, 1976

(Interdepartmental Report)

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During April 1977 the Statewide Salmon Stock Separation project examined and analyzed scales taken from 1976 fall stocks of Sheenjek, Toklat and Delta River chum salmon. This report will summarize results from the 1976 year class analysis and present results of analysis conducted on scales collected from Sheenjek, Toklat and Anvik River chum stocks during 1974.

All scales were examined at a magnification of 100x utilizing a Leitz Prado Universal projection microscope. Scale images were projected onto a table surface and drawings were made of circuli along the 20° ventral axis of the scale. Numerical data was produced from the scale drawings utilizing a digitizer and linear encoder. Analysis was conducted on the University of Alaska Honeywell computer utilizing SPSS programs.

1976 Sheenjek, Toklat, Delta Analysis

Scales from Sheenjek, Toklat and Delta River chums were examined during the spring of 1977. The scale characteristics recorded were the width and number of circuli for the following portions of the scales: focus to outside edge of supplementary check, supplementary check to inside edge of the first annulus, first annulus (i.e. first marine winter), outside edge of the first annulus to the inside edge of the second annulus (i.e., second marine summer), second annulus (i.e. second marine winter). Because of a high proportion of resorbed scale margins, none of the scales were read beyond the second annulus. Only age $4_1$ chums were examined due to sample size limitations.

The discriminant analysis program examines the variability between rivers for each of the scale characteristics. The characteristics which

provide the best discrimination are selected and used to create classification equations. Classification accuracy is then tested by classifying samples used to create the equations as if they were unknown samples. The resulting estimates of accuracy approximate that which could be obtained in actual classification of samples of unknown stock compostion.

The classification matrix from an analysis using all ten scale characteristics is presented in Figure 1. Sheenjek fish separated quite well from Toklat and Delta. Of the Toklat fish, 66.7% were correctly classified with 23.5% misclassified as Delta. Classification accuracy for Delta River was 72.2% with slightly higher misclassification as Sheenjek than Toklat. Overall classification accuracy was 75.6% which compares favorably with many 3-way analyses conducted on sockeye salmon. The scale characteristics which provided the best separation were the number of circuli in the second marine summer followed by the distance from the supplementary check to the end of the annulus and the width of the supplementary check.

Figure 1. Classification matrix from 1976 Sheenjek, Toklat and Delta River age $4_1$ chum salmon discriminant analysis.

| | Predicted Group Membership | | |
|---|---|---|---|
| Actual Group | Sheenjek | Toklat | Delta |
| Sheenjek (n=44) | 39 (88.6%) | 2 (4.5%) | 3 (6.8%) |
| Toklat (n=51) | 5 (9.8%) | 34 (66.7%) | 12 (23.5%) |
| Delta (n=36) | 6 (16.7%) | 4 (11.1%) | 26 (72.2%) |

In an analysis using only first year characteristics, the accuracy of Sheenjek and Delta classification decreased slightly whereas Toklat fell to 47%, with most of the increased error being misclassification as Sheenjek. Using only the width and number of circuli in the supplementary check achieved 51% overall accuracy. The accuracy of the Toklat classification increased from the level achieved using all first year scale characters (47% to 57%) and was due mostly to reduced misclassification of Toklat as Delta.

1974 Sheenjek, Toklat, Anvik Analysis

Scales from Sheenjek, Toklat and Anvik river chum salmon were examined during the fall of 1977. The scale characteristics recorded for age $4_1$ fish were identical to those recorded for the 1976 analysis. Similar measurements were recorded for age $3_1$ fish through the end of the first annulus only. A high proportion of resorbed scale margins prevented measurement of scales beyond areas indicated. Discriminant analysis was used as in the 1976 analysis.

Multiple anlayses were run to examine separability of the following groups.

1. Sheenjek, Toklat - age $3_1$
2. Sheenjek, Toklat - age $4_1$
3. Sheenjek, Toklat, Anvik - age $3_1$
4. Sheenjek, Toklat, Anvik - age $4_1$

Since resorbed scale margins allowed relatively few usable scale characteristics, computed characters were generated using those measured directly from the scales. Sums and ratios were computed for circuli counts and distance measurements of respective portions of the scale.

Additionally, log values of measured characters and the ratio of fish length to circuli counts and width measurements were computed and used in all analyses. Classification matricies presented within the text result from analyses using measured characteristics only. Generally use of computed variables improved classification only slightly if at all. Discussion is presented where improvement was noted.

The 2-way classification of Sheenjek, Toklat age $3_1$ chum salmon yielded an overall accuracy of 67.6% (Figure 2). Sheenjek (.379) had a higher misclassification probablily than Toklat (.284). The scale characteristics which provided the best separation were the number of circuli in the supplementary check followed by the distance and number of circuli in the first marine winters growth. Frequency diagrams for each of these characteristics are presented in Appendix Figure 1, 2 and 3.

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Figure 2. Classification matrix from 1974 Sheenjek, Toklat age $3_1$ discriminant analysis.

| | Predicted Group Membership | |
|---|---|---|
| Actual Group | Sheenjek | Toklat |
| Sheenjek (n=58) | 36 (62.1%) | 22 (37.9%) |
| Toklat (n=81) | 23 (28.4%) | 58 (71.6%) |

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In an analysis using only supplementary annulus characteristics (number of circuli and width) identical results were obtained. In another analysis using the computed natural log of the number of circuli in the supplementary check, the natural log of the number of circuli in the first winters growth and the width of the first winters growth, overall classification accuracy increased slightly from 67.6% to 69.78%.

Analysis of age $4_1$ fish from Sheenjek and Toklat rivers yielded an overall accuracy of 70.8% and the classification matrix presented in Figure 3. Again Sheenjek (.382) had a greater probability of misclassification than Toklat (.236). The distance from the end of the supplementary check to the beginning of the first marine winter followed by the number of circuli in the second marine summer and the width of the supplementary check provided the best discrimination.

Figure 3. Classification matrix from 1974 Sheenjek, Tokalat age $4_1$ discriminant analysis.

| | Predicted Group Membership | |
|---|---|---|
| Actual Group | Sheenjek | Toklat |
| Sheenjek (n=34) | 21 (61.8%) | 13 (38.2%) |
| Toklat (n=55) | 13 (23.6%) | 42 (76.4%) |

In an analysis using the width from the end of the supplementary check to the beginning of the first marine winter, the number of circuli in the second summer growth, the computed length divided by the number of circuli in the second winter, the computed length divided by the width of the first marine winter, and the width of the scale to the end of the second summers growth improved classification results slightly from 70.8% to 73.03%. Insignificant increases in accuracy were obtained by using normalized data (natural log values for various characteristics).

The 3-way classification of age $3_1$ chums from Anvik, Sheenjek and Toklat resulted in an overall accuracy of 59.1% (see Fig. 4). Recall that due to random chance alone 33.3% of the fish would be correctly classified. As was expected, summer run Anvik chums proved to be quite distinct from fall run Sheenjek and Toklat chums. Again Sheenjek fish

were more often misclassified as Toklat (34.5%) than Toklat as Sheenjek (21.0%). The scale characterisitcs which proved most valuable in discrimination were the number of circuli in the supplementary check followed by fish length and the width of the first winters marine growth.

Figure 4. Classification matrix from 1974 Sheenjek, Toklat, Anvik age $3_1$ discriminant analysis.

| | Predicted Group Membership | | |
|---|---|---|---|
| Actual Group | Sheenjek | Toklat | Anvik |
| Sheenjek (n=58) | 31 (36.2%) | 20 (34.5%) | 17 (29.3) |
| Toklat (n=81) | 17 (21.0%) | 57 (70.4%) | 7 (8.6%) |
| Anvik (n=20) | 4 (20.0%) | 0 (0.0%) | 16 (80.0%) |

In analyses using computed characteristics slight increases in accuracy were obtained. Most of this increase was reduced misclassification of Sheenjek as Anvik.

Three way analysis of age $4_1$ Sheenjek, Toklat and Anvik fish resulted in a somewhat better (62.9%) overall classification accuracy (see Figure 5). Sheenjek and Toklat had relatively equal probabilities of misclassification to each other. Again, summer run Anvik fish were found quite distinct from fall Sheenjek and Toklat chums. Anvik chums were correctly classified 68.6% of the time and had equal probabilities of misclassification as Sheenjek or Toklat. The scale charcters providing the best separation were the width of the second marine summers growth followed by fish length, the distance measurement from the end of the supplementary check to the beginning of the first annulus, the number of circuli in the supplementary check and the number of circuli in the second marine summers growth.

Figure 5. Classification matrix from 1974 Sheenjek, Toklat, Anvik age $4_1$ discriminant analysis.

| Actual Group | Predicted Group Membership | | |
|---|---|---|---|
| | Sheenjek | Toklat | Anvik |
| Sheenjek (n=34) | 20 (58.8%) | 8 (23.5%) | 6 (17.5%) |
| Toklat (n=55) | 15 (27.3%) | 32 (58.2%) | 8 (14.5%) |
| Anvik (n=70) | 11 (15.7%) | 11 (15.7%) | 48 (68.6%) |

An analysis using the computed characteristics of fish length divided by the interval distance of each portion of the scale, fish length alone and the computed characteristic of fish length divided by the number of circuli in the supplementary check improved overall classification accuracy from 62.9% to 66.67%. This increase was reflected largely in reduced misclassification of Anvik fish (74.3% correctly classified).

Summary

Although it was hoped classification accuracies would prove better than our results, several possible factors must be considered when interpreting these findings.

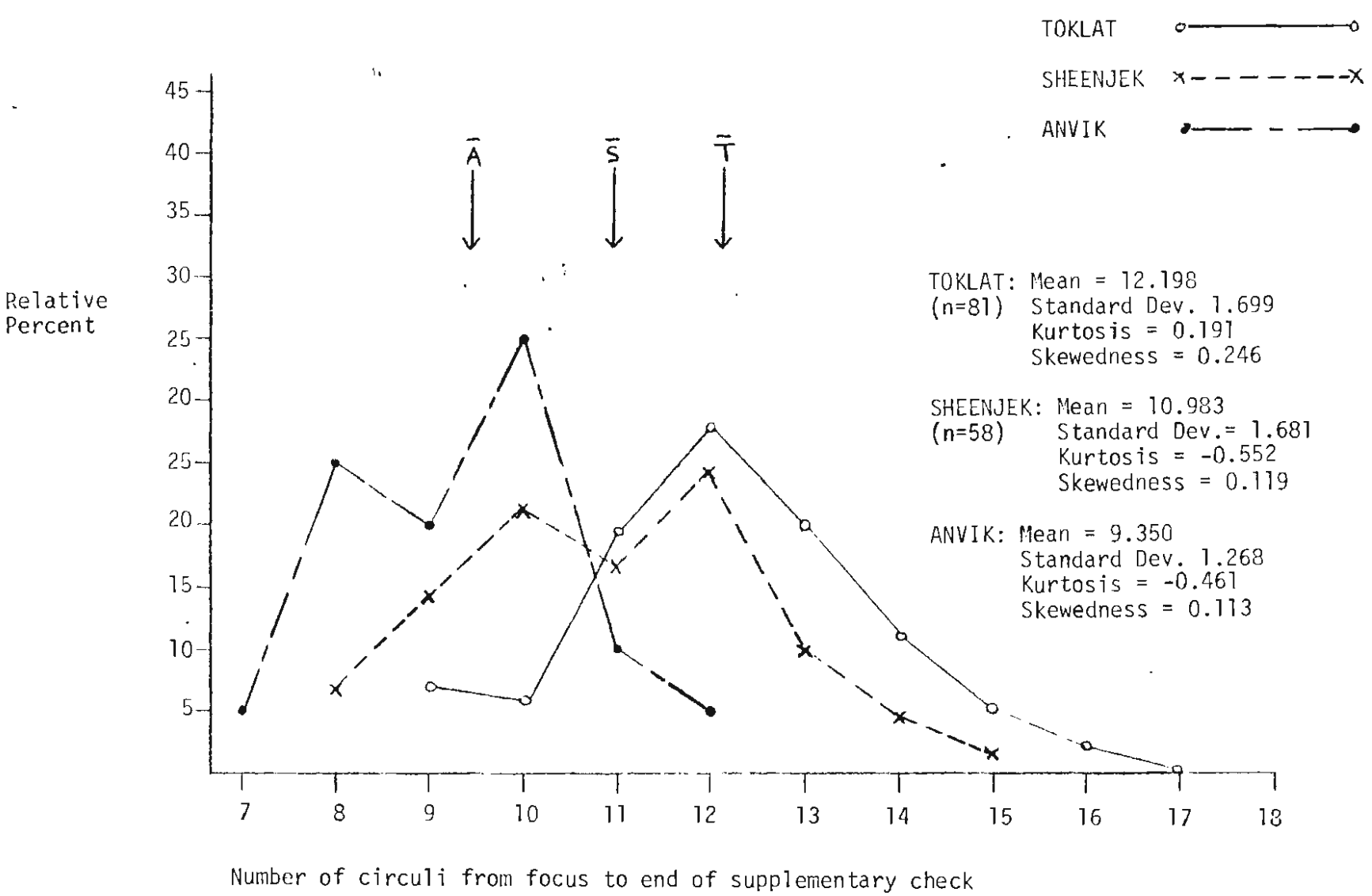
1. Sampling - In order to attempt classification of stocks of unknown origin a known sample which accurately reflects those stocks in question is necessary. Spacial and/or temporal sampling vagaries within a known sample could have dramatic effects upon how representative a sample might be. Samples collected during a short period of time in a limited area may accurately represent only particular substocks within a system.
2. Sample Size - Chum salmon, being a non freshwater rearing species, may not have the opportunity to reflect as much differential environmental information on the scale as do freshwater rearing species. Intensified sampling with its associated reduction of variability is one option that may serve to partially overcome this factor.
3. Ageing - A large proportion of resorbed scales were noted in all samples. Ageing scales of this type is particularly difficult. A valid analysis can be performed only on scales taken from fish of the same brood year and age class.

Analysis of both year classes seems promising in that neither of the samples were designed with the separation of stocks in mind. Increased sampling efforts during 1976 might well be reflected in the superior classification accuracies obtained in that analysis. Three-way classification accuracies presented within the paper compare fairly well with many 3-way

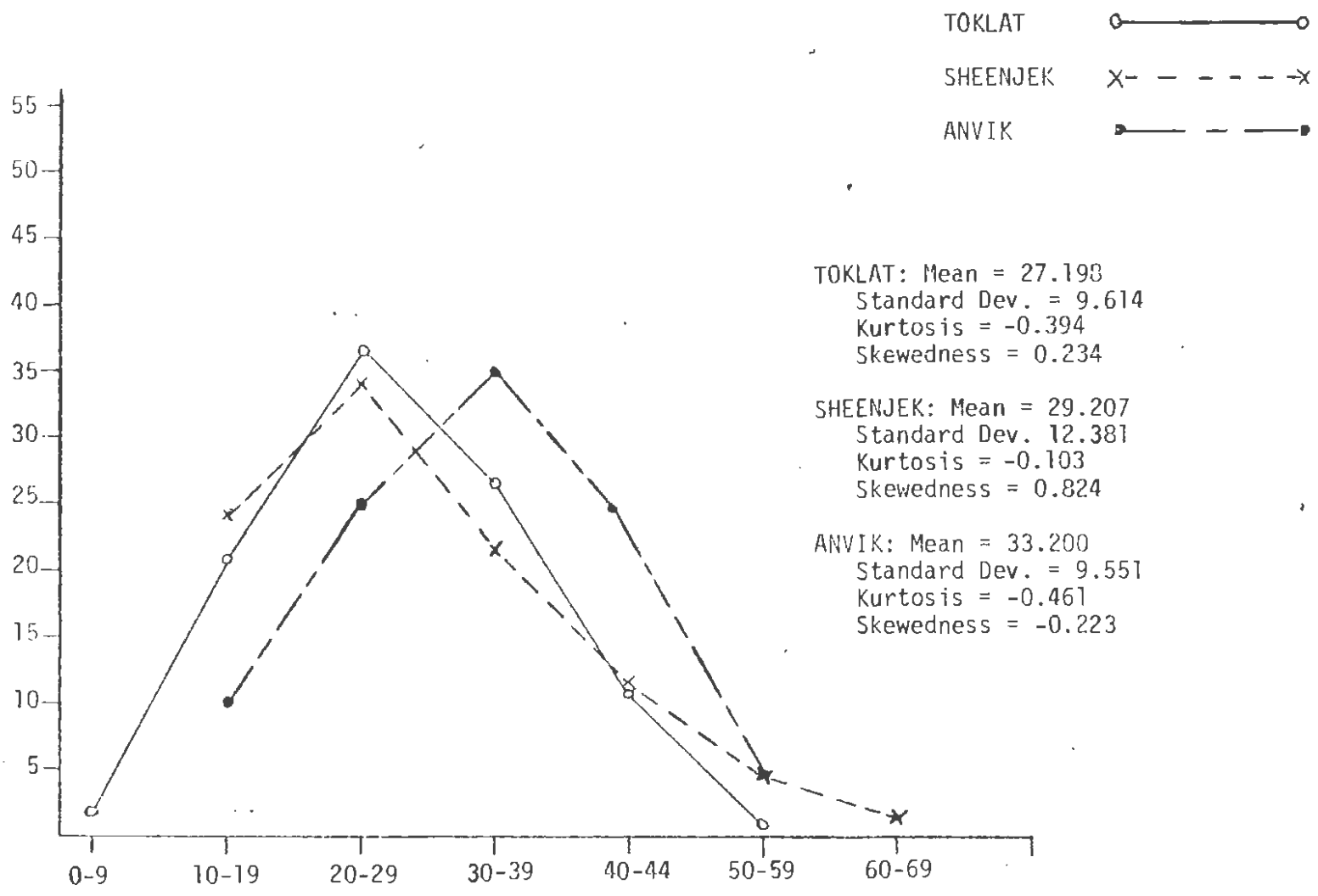
analyses performed on other species. An overall classification accuracy of 66% on a 3-way analysis approximately doubles the frequency of correct classification that could be obtained by chance alone.

Future applications of scale analysis for stock separation will need to consider sampling and ageing problems mentioned above. Known samples will need to reflect at least the major chum salmon systems of the Yukon River. A combination of scale analysis and right-bank, left-bank stocks indicated by tagging information may yield a viable stock separation tool for Yukon River chums.

Appendix Figure 1. Relative percent of number of circuli from focus of scale to the end of of the supplementary check for Toklat and Sheenjek age 3$_1$ chum salmon.



Appendix Figure 2. Relative percent of interval width measurements for the first marine winters growth for Toklat, Sheenjek and Anvik River age $3_1$ chum salmon.



Appendix Figure 3. Relative percent of the number of circuli in the first marine winters growth for Toklat, Sheenjek and Anvik River age $3_1$ chum salmon.